3 Early Treatment: Interceptive Guidance of Occlusion including Serial Extraction followed by Mechanotherapy

Jack Dale

The principle of early treatment, associated with the extraction of primary teeth followed by the removal of permanent teeth, was first described by a Frenchman named Robert Bunon in his Essay on the Diseases of the Teeth published in 1743, more than 260 years ago.

The Logic of “Serial Extraction”

Kjellgren, a Norwegian, is credited with the introduction of the term “serial extraction,” in 1929 (Kjellgren 1947–48). In my opinion, this term is somewhat dangerous because it tends to create a misconception of simplicity, implying that there is nothing more involved than the mere extraction of teeth.

Hotz’s term “guidance of eruption,” or the term used in the title of this chapter, “guidance of occlusion,” are better. These terms are comprehensive; they suggest that a thorough knowledge of growth and development of the dentition and the craniofacial complex is required in making a number of key decisions throughout the developmental period.

The most crucial decision that we, as specialists in orthodontics, are required to make is, “Do we extract teeth or not in the correction of a malocclusion?” Adding the dimension of time, complicating it with growth and development, and carrying out extraction in a serial manner is even more demanding. Serial extraction is not easy, as so many mistakenly believe, and should never be initiated without a comprehensive diagnosis.

In truth, one can extract teeth with the greatest of ease during serial extraction procedures. If the basic principles of diagnosis are ignored, however, the result will be failure and disappointment. It will not only be injurious to the patient but will harm the practitioner’s reputation and, ultimately, our specialty of orthodontics. The single most important reason for failure is lack of knowledge and lack of preparation on the part of the clinician.

Serial extraction based on a thorough knowledge and a sound diagnosis and carried out carefully and properly on a select group of patients can be a valuable treatment procedure, and it is a treatment procedure. There are those who do not consider interceptive guidance with serial extraction as treatment. But it is this type of treatment that justifies our title “doctor.” We are treating a potential major malocclusion utilizing biological principles. Must we be so mechanically oriented that we only consider treatment with appliances? Should we not also be applied biologists?

Serial extraction is an excellent treatment procedure. It can reduce appliance treatment time, the cost of treatment, discomfort to patients, and time lost by both the patients and their parents. It is logical to intercept a malocclusion as early as possible and to reduce or, in rare instances, avoid multibanded-multibracket mechanotherapy at the sensitive teenage period. Why allow an unfavorable dental, skeletal, or soft-tissue relationship to exist for a number of years if it can be wholly or partially corrected early with a minimum of multibanded-multibracket treatment time?

Pioneers and Followers

I consider myself truly fortunate to have learned the basic principles of growth and development of the dentition and the craniofacial complex from a world-renowned educator, research scientist, and authority on this subject, Dr. Coenraad Moorrees at Harvard-Forsyth Orthodontic Program, Harvard University. Dr. Moorrees has been quoted by former students as saying the two things he values most highly are the understanding of craniofacial growth and skill as a diagnostician, and that he believes that the salvation of our specialty lies in nurturing its theoretical foundations (personal communication). When I returned to Toronto from Harvard in 1961, I felt strongly that I must utilize Dr. Moorrees’ “theoretical foundations” to become a “skilled diagnostician” in the clinical practice of orthodontics and in the day-to-day caring for my patients.

For 48 years, I have treated many patients utilizing serial extraction with success and satisfaction and have substantiated my use of this procedure with records taken up to 35 years after treatment. The importance of diagnosis cannot be emphasized enough. To differentiate, categorize, and treat serial extraction patients specifically and successfully on a routine basis requires a thorough understanding of the fundamental principles of diagnosis. It is, without question, the key to success.

Several diagnostic analyses related to the teeth and the face, including proportional facial analysis (PFA), craniofacial analysis (CFA), total space analysis (TSA) of the dentition and dental age analysis (DAA) are discussed in the textbook, Orthodontics, Current Principles and Techniques (Graber et al., 2005).

The extraction of teeth was performed long before Edward Angle gave his first major paper to the dental profession in 1887. For our purposes, however, the controversy over extraction began with him. In the beginning, it involved such practitioners as Angle himself, Case, Dewey, Grieve, and others. Later, it included Tweed,
Strang, and Brodie. It is still a controversial procedure today, over a century later!

I like to think that the controversy is restricted basically to the borderline problems. It is difficult to believe that there are orthodontists who treat all orthodontic problems without the extraction of teeth, or who treat all orthodontic problems with extractions. If that is the case, it is tantamount to ignoring morphogenetic pattern and the necessity for diagnosis. I prefer to believe that the majority of practitioners treat patients as individuals and on the basis of a sound diagnosis, extracting teeth in high angle alveolar dental protrusion and tooth-size–jaw-size discrepancies, and treating low-angle, excessive overbite, and spaced dentitions with relatively small teeth on a nonextraction basis.

“Out of the great number of faces that have been formed since the creation of the world, no two have been exactly alike.”—William Hogarth.

Serial Extraction

According to the Burlington Growth Study (Burlington Orthodontic Research Project, Report No. 3, 1957), 34% of 3-year-old children enjoy a “normal” occlusion. By the time they reach 12 years of age, only 11% have a “normal” intercuspal, a reduction of 23%. This is attributed to local environmental factors: for example, crowded dentitions resulting from a loss of arch length caused by the premature loss of primary teeth.

Of the remaining 66% of 3-year-old children destined to suffer the ravages of malocclusion, 41% are in a Class I dental relationship, 23% are in a Class II, and only 2% are in Class III. By the time these children reach 12 years of age, 55% have Class I malocclusions, 32% have Class II, and 2% still have Class III, a total increase of 23%. Again, this increase is due primarily to local environmental factors.

Serial extraction is an interceptive procedure designed to assist in the correction of hereditary crowding. Since the malocclusions of the 66% of 3-year-old children are hereditary in nature, with a significant number of tooth-size–jaw-size discrepancies, serial extraction is an invaluable adjunct to interceptive treatment. This is especially true in the 41% Class I malocclusions (Case Study 3.2) and, to a lesser extent, the 23% Class II (Case Study 3.3).

Class I malocclusions are ideal for serial extraction because the teeth and jaws are in a favorable relationship, and successful treatment is possible with a minimum of mechanotherapy. The ideal conditions for serial extraction are:

* A true, relatively severe, hereditary tooth–size–jaw–size discrepancy
* A mesial step mixed dentition developing into a Class I permanent dentition relationship
* A minimal overjet relationship of the incisor teeth
* A minimal overbite, and
* A craniofacial pattern that is slightly hyperdivergent and orthognathic with a moderate alveolar dental protrusion

My chapter “Interceptive guidance of occlusion with emphasis on diagnosis” in the Graber et al. (2005) textbook outlines and illustrates several signs of a true, hereditary tooth-size–jaw-size discrepancy, which are basic to serial extraction, as well as several signs of environmental crowding, which are not. In orthodontics we are interested in the ultimate size and the rate of maturation of the jaws, that is, the ultimate size, the rate of maturation, and the emergence of the teeth into the oral cavity and the ultimate treatment result. We are also interested in the adolescent growth spurt of the body and its relation to the accelerated growth in the craniofacial complex. Finally, we must be interested in the relationship between chronological age, skeletal age, and dental age as set out by Moorrees and his associates (see their work between 1961 and 1966, listed in the extensive bibliography at the end of this chapter).

Utilizing information derived from the longitudinal studies of Moorrees and associates, the clinician who is attempting to guide the teeth into a favorable occlusion can more accurately predict important events in the development of the dentition. For instance, we know that the unerupted permanent tooth is literally standing still until half of its root is formed. With this knowledge, we would hesitate to extract the primary first molar if its permanent successor had less than one-half root formation. This would delay rather than accelerate the eruption of the premolar.

We also know that teeth emerge into the oral cavity when three-quarters of their roots are formed. It requires 2½ years for the canine root to go from one-quarter to one-half root length and a 1½ years to go from one-half to three-quarters, when, theoretically, it emerges into the oral cavity. Therefore, if you see a canine root in a radiogram at one-quarter root, you can predict that it will emerge in four years. It requires 1¼ years for the first premolar root to go from one-quarter to one-half root length and 1½ years to go from one-half to three-quarters. Armed with information like this, the clinician, on inspecting the periapical radiogram, can predict the emergence of these teeth and can time their extraction more precisely.

The Multibanded-Multibracket Appliance

When the interceptive guidance of occlusion and serial extraction phase has been completed, the multibanded-multibracket appliance is placed, and active treatment is initiated utilizing, in my case, the modern concepts of The Charles H. Tweed International Foundation for Orthodontic Research and Education developed by Charles H. Tweed, Levern Merrifield, and their colleagues over more than five decades (see work by Tweed, Merrifield et al., from 1946 to 2000 listed in the bibliography).

The treatment objectives after interceptive guidance are:

* Closure of residual extraction spaces
* Improvement of axial inclination of individual teeth
* Correction of rotations
* Correction of the midline discrepancy
* Correction of the residual overbite
* Correction of the residual overjet
* Correction of crossbites
* Refinement of the intercuspation of individual teeth
* Improvement and coordination of arch form, and
* Correction of the class II relationship in some class II patients. (Case Study 3.3)

Charles Tweed’s primary objectives in treatment, goals for all orthodontists, include:
Dental health of the dentition and the supporting and surrounding structures
- Esthetics, including ideal alignment, occlusion and smile
- Balance and harmony within the craniofacial complex, reflected in the facial soft-tissue, especially in the profile
- Function, including canine protected occlusion, incisal guidance and recovery
- Treatment complementing growth and development, including vertical control and a favorable mandibular response
- Stability, respecting the limits of the dentition

These are excellent treatment goals, but they are too general. We must strive for specific treatment goals that are interrelated with one another:
- Counterclockwise (upward and forward) rotation, vertical control with a favorable mandibular response
- FMA reduced, vertical control with a favorable mandibular response
- ANB reduced, skeletal discrepancy reduction by maxillary control with a favorable mandibular response
- Vertical control, high-pull headgear, and serial extraction resulting in a favorable mandibular response
- Alveolar dental correction, uprighting mandibular incisors with anchorage and the extraction of bicuspid teeth
- Crowding corrected, anchorage and extraction
- Anchorage preparation that assists in the retraction of the anterior teeth and the correction of the class II relationship
- Occlusal plane control, vertical control of the posterior teeth, and uprighting of mandibular incisors; flattening of the occlusal plane
- Balance and harmony within the craniofacial complex reflected in the soft-tissue profile, favorable mandibular response, and a reduction of alveolar dental protrusion
- Ideal occlusion in balance and harmony with the supporting and surrounding tissues
- Overtreatment, recovery rather than relapse
- Stability, respecting the limits of the dentition

These specific objectives are illustrated in the comprehensive case reports of G.L. (10 years after treatment (AT)), M.R. (20 years AT) and J.O. (25 years AT), and supported by the results 5–35 years after treatment.

The Tweed–Merrifield Edgewise Appliance Technique

The modern concepts of The Tweed–Merrifield Edgewise Appliance Technique can be summarized as follows.

It was the genius of Dr. Edward Hartley Angle that created the “edgewise appliance.” He introduced it in 1928, following intensive experimentation with The “E” arch, the Pin and Tube, and the Ribbon Arch appliances, which he had developed. The world owes to him a debt of gratitude as the real founder and father of modern orthodontics. His work was based on science, developed on dexterity, and consummated in art. He visualized the whole story from beginning to end and he made his vision become a reality.

In 1930, just before he died, he said, “I have finished my work. It is as perfect as I can make it.” But we know that this inventive genius, who was always thinking, experimenting, selecting, and discarding, never satisfied with the results at hand, always pondering over possible improvement, would be the last to declare perfection, even if he had attained it. He must have known, even when he made this statement on his deathbed, that his work must go on. He must have been at peace with the knowledge that he had finally found “the right man” to carry out his “beautiful work”: Dr. Charles H. Tweed.

The Tweed Foundation has over 100 letters written by Angle to Tweed from 1928 to Angle's death in 1930. During these two years, Angle urged his young disciple to dedicate his life to the development of “the edgewise appliance.” Tweed did just that. He concentrated his efforts on the development and advancement of “the edgewise appliance” for 43 years, until his death in 1970, and he established the first pure edgewise practice in the United States.

In 1953, Dr. Levern Merrifield became active in The Tweed Foundation and succeeded Tweed in 1970 as the Director of the Tweed Course. He continued in his leadership role until his death in 2000. Tweed “diagnosed” a serious problem in orthodontics: facial imbalance and disharmony associated with alveolar dental protrusion and a tooth-size–jaw-size discrepancy. He observed that by creating space with the extraction of teeth and with the correction of the alveolar dental protrusion by uprighting incisors into the space provided, he corrected the facial imbalance and disharmony.

Merrifield devoted his career to the improvement of the “treatment” of this problem to such an extent that the Tweed–Merrifield Edgewise Appliance is one of the most precise instruments for the routine correction of major malocclusions that exists in the world today.

The goal for the future is “prevention,” to establish a soft tissue profile in balance and harmony without imbalance and disharmony occurring first.

Thus, it is important to examine potential orthodontic patients by 7 years of age and to determine whether the child could benefit by a “Phase I, Interceptive Guidance,” serial extraction period of treatment prior to a “Phase II Tweed–Merrifield Multibanded-Multibracket Edgewise Appliance” treatment when most of the permanent teeth have emerged at 11.5 years of age, prior to the sensitive teenage period.

This chapter discusses the treatment of patients who have benefited from a “Phase I, Interceptive Guidance” serial extraction period of treatment prior to a “Phase II Multibanded-Multibracketed Tweed–Merrifield Edgewise Appliance” period from roughly 11.5 to 13 years of age.

The Tweed–Merrifield Edgewise Appliance

The Tweed–Merrifield edgewise appliance is a neutral bracket appliance with which all the treatment is carried out in wire manipulation for individual situations in individual patients. This contrasts with the straight-wire appliance in which the treatment is primarily in pretorqued, preangled brackets.
The Tweed–Merrifield edgewise appliance is a series of force systems that include:

- Dentition preparation, including leveling of the brackets and retraction of the canines utilizing an auxiliary high-pull headgear
- Dentition correction, including 10–2 sequential mandibular anchorage preparation and maxillary Class II correction
- Dentition completion, including overtreatment into a super Class I relationship
- Dentition recovery, including a transition from overtreatment occlusion (transitional occlusion) to normal functional occlusion

The results are then retained for 1–2 years depending on the malocclusion being treated.

The modern concepts of the techniques can be summarized as follows:

- Directional force systems
- Sequential 10–2 anchorage
- Readout
- Prescription arches
- Performance testing

The directional force systems technique employs a group of force systems utilizing directional control to position the teeth precisely in both the maxilla and the mandible so that they will be in harmony with their environment.

The sequential 10–2 anchorage concept is a sequential anchorage system wherein the archwire stabilizes 10 teeth while 2 teeth receive the active force. Instead of 12 teeth being simultaneously involved in the anchorage preparation, only two teeth receive active force. The sequence begins with the second molars and is completed with the second premolars. When this type of improved anchorage preparation is used, there is less risk that the mandibular dentition will move unfavorably downward and forward, and patient cooperation is not as crucial.

With readout the objectives of orthodontic treatment can be defined by accurate measurement. Tooth axial inclination and movement can be predetermined, monitored during treatment, and checked for accuracy of final placement.

Prescription arches involve the tabulation of second-order bends (vertical) angulation associated with 10–2 anchorage and readout. They also permit the precise measurement and tabulation of buccolingual axial inclinations of teeth so that third–order bends (torque) can be incorporated in the archwire. Finally, they include first-order bends (horizontal). These prescription arches are designed specifically for individual malocclusions.

Performance testing is a relatively recent development involving the serial measurement of tooth movement and dental relationships so that treatment progress can be evaluated.

This particular edgewise appliance, originally designed by Tweed and modified by Merrifield and his associates, is the precision instrument utilized in achieving treatment goals. It is characterized by simplicity, efficiency, and comfort; it is hygienic and aesthetic and, above all, it has wide range versatility (Vaden et al. 2000).

When all bands and brackets are removed and retainers are placed, a critical stage in the correction of the malocclusion occurs. It is referred to as the “period of recovery.” If the corrective procedures only barely achieve the normal relationship of teeth, there will be an inevitable relapse. Any change that occurs will be away from ideal occlusion. If treatment is completed by overcorrection, however, all changes that take place during the recovery period will be toward the ideal relationship.

This treatment protocol provides favorable circumstances for arriving at Tweed’s original objectives.

With The Tweed–Merrifield direction force edgewise technology, patients are routinely treated in 18–20 months, primarily because of the efficiency and control of the appliance (see Case Study 3.1). When interceptive guidance of occlusion is combined with the edgewise appliance in the correction of specific malocclusions, it reduces mechanotherapy even further (see Case Studies 3.2 and 3.3).

To quote Charles Tweed, “When facial deformity has been corrected and mental anguish eliminated, a dull and unhappy facial expression becomes bright and happy. What greater reward could any orthodontist want or expect?” One could add, “The earlier this occurs the better” (Fig. 3.1).
Clinical Case Studies

Case Study 3.1  Patient G. L.

- Male
- 14.9 years of age
- Vertical growth
- Hyperdivergent facial pattern (FMA, 30°)
- Skeletal discrepancy: retrognathic mandible (ANB, 9°), (SNB, 71°)
- Maxillary-mandibular alveolar dental protrusion (Z, 55°)
- Class II Division 1 malocclusion
- Tooth-size–jaw-size discrepancy
- Extraction of four first premolar teeth
- Tweed–Merrifield edgewise mechanotherapy

G. L.’s case represents conventional orthodontic treatment, without the advantage of a period of interceptive guidance of occlusion. The treatment was successful and satisfies the general Tweed objectives, but it falls short of the more specific objectives, especially in mandibular response. An earlier and longer period of vertical control could have resulted in a more significant counterclockwise rotation of the mandible. Utilizing serial extraction, a form of vertical control, this has been accomplished many times in our practice as indicated in Case Study 3.2, serial extraction Class I, and in Case Study 3.3, serial extraction Class II.

G. L.—Total Space Analysis

<table>
<thead>
<tr>
<th>Anterior Arch</th>
<th>Posterior Arch</th>
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<tbody>
<tr>
<td><strong>REQUIRED</strong></td>
<td><strong>REQUIRED</strong></td>
</tr>
<tr>
<td>Teeth: 1, 2, 3</td>
<td>Teeth: 7, 8</td>
</tr>
<tr>
<td>-40.0</td>
<td>-46.0</td>
</tr>
<tr>
<td>Ceph. correction</td>
<td></td>
</tr>
<tr>
<td>-17.0</td>
<td></td>
</tr>
<tr>
<td>Soft tissue</td>
<td></td>
</tr>
<tr>
<td>–</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>TOTAL</strong></td>
</tr>
<tr>
<td>-57.0</td>
<td>-46.0</td>
</tr>
<tr>
<td><strong>AVAILABLE</strong></td>
<td><strong>AVAILABLE</strong></td>
</tr>
<tr>
<td>+39.0</td>
<td>+32.0</td>
</tr>
<tr>
<td><strong>DEFICIT</strong></td>
<td><strong>DEFICIT</strong></td>
</tr>
<tr>
<td>-18.0</td>
<td>+3.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>TOTAL</strong></td>
</tr>
<tr>
<td>-5.0</td>
<td>-11.0</td>
</tr>
<tr>
<td><strong>TOTAL DEFICIT</strong></td>
<td><strong>TOTAL DEFICIT</strong></td>
</tr>
<tr>
<td>-34.0</td>
<td>-11.0</td>
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</table>

Total space analysis based on research conducted at The Charles H. Tweed Foundation (Merrifield 1978) depicts a significant anterior deficit (−18.0) and posterior deficit (−11.0), indicating the extraction of four first premolar and four third molar teeth.

Fig. 3.1.1  Face before treatment. Note retrognathic mandible, with resulting recessive chin, and lack of proportion of the soft-tissue profile. Malalignment of the maxillary anterior teeth is evident when the patient smiles. There is a lack of balance and harmony when the patient’s lips are closed.
Fig. 3.1.2  Cephalometric tracing before treatment. Note skeletal discrepancy (ANB, 9°) resulting from retrognathic mandible (SNB, 71°) and mandible alveolar dental protrusion (IMPA, 107°). Dotted line represents alveolar dental correction objective to a more upright position of the mandibular incisors, which will result in a more balanced soft-tissue profile.

G.L.—Total Space Analysis Difficulty

<table>
<thead>
<tr>
<th>Anterior arch</th>
<th>Value</th>
<th>Difficulty Factor</th>
<th>Difficulty</th>
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<tr>
<td>Tooth arch discrepancy</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Ceph. discrepancy</td>
<td>17.0</td>
<td>1.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>0.0</td>
<td>0.5</td>
<td>–</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18.0</td>
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<th>Mid arch</th>
<th>Value</th>
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<tr>
<td>Tooth arch discrepancy</td>
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<td>1.0</td>
<td>2.0</td>
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<td>Curve of Spee</td>
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<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>TOTAL</td>
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<table>
<thead>
<tr>
<th>Posterior arch</th>
<th>Value</th>
<th>Difficulty factor</th>
<th>Difficulty</th>
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<tr>
<td>Tooth arch discrepancy</td>
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<tr>
<td>Expected increase</td>
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<td></td>
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<tr>
<td>TOTAL</td>
<td>11.0</td>
<td>0.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Horizontal occlusion discrepancy Class II–III</td>
<td>10.0</td>
<td>2.0</td>
<td>20.0</td>
</tr>
<tr>
<td>TOTAL DIFFICULTY</td>
<td></td>
<td></td>
<td>49.0</td>
</tr>
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</table>

Total difficulty 49, primarily due to cephalometric discrepancy, alveolar dental protrusion (17.0), and the Class II relationship (20.0).
Fig. 3.1.3  Cephalometric analysis before treatment, emphasizing the six measurements that are important in determining success or failure in treatment based on research conducted at The Charles H. Tweed Foundation (Gramling 1987).

FMA indicates a high angle or low angle facial pattern. A favorable response reduces the angle.

SNB indicates mandibular relationship. A favorable response increases the angle.

ANB indicates skeletal discrepancy. A favorable response maintains the angle between 1 and 5°.

OP indicates treatment control. If treatment is controlled and if the posterior teeth are not extruded and the mandibular incisors are not “dumped forward”, the occlusal plane will flatten.

Z: A small Z angle indicates a large alveolar dental protrusion. A favorable response would increase the angle.

The posterior face height to anterior face height ratio (PFH/AFH) indicates mandibular response. If the ratio increases, the mandible rotates favorably to a lower angle face. If the ratio decreases, the mandible rotates unfavorably in the opposite direction.

Parameter | Normal range | Patient | Difference
--- | --- | --- | ---
FMA | 22–28 | 30 | 30 – 28 = 2
ANB | 1–5 | *9 | 9 – 5 = 4
Z | 70–80 | 55 | 70 – 55 = 15
OP | 8–12 | 6 | 8 – 6 = 2
SNB | 78–82 | *71 | 78 – 71 = 7
PFH/AFH | 0.62–0.72 | 0.61 (55/91) | 0.67 – 0.61 = 6

Total difficulty: 159.

* Significant difference

G.L.—Cranial Facial Analysis with Difficulty before Treatment (B.T.)

Fig. 3.1.4  Dentition before treatment. Note the Class II malocclusion and the protruding and malaligned maxillary anterior teeth. Because of the protrusion, one incisor has been fractured accidentally.

The patient’s orthodontic problem is categorized as severe (208, > 120).

It is severe primarily because of the cranial facial factors (159, see CFA with Difficulty), and specifically it is severe because of the skeletal discrepancy (ANB, 9°: 60). More specifically, it is due to the retrognathic mandible (SNB, 71°: 35), which is also reflected in the soft-tissue profile (Z, 55°: 30).